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Changes in edaphic factors and microarthropod communities after clearing and burning in a tropical rain forest in French Guyana

Jean-Marie Betsch & Jorge Paulo Cancela da Fonseca

Betsch, J.-M., Muséum Nat. Hist. Nat., Ecologie générale, URA 689 C.N.R.S., F-91800 Brunoy, France
Cancela da Fonseca, J. P., C.N.R.S. and University Paris 7, Biologie végétale & Ecologie forestière, F-77300 Fontainebleau, France

A study of mite and springtail communities in relation to some edaphic factors (soil organic matter, moisture content, amount of litter) was carried out in a cleared and burnt area in a tropical rain forest during the early stages (0–5 years), and after 16 years of recovery. The relationships between animal communities, sites and stages of regrowth were studied with the aid of Spearman correlation analysis, Mann-Whitney heterogeneity test and correspondence analysis. The correlations between the mesofauna and the moisture content differed in some groups mainly according to the hydric profile (inversed in recently burnt soils). The correspondence analysis revealed the relationships in space and time between the sites and their characteristics during the soil restoration.

1. Introduction

There are a lot of data on clear-cutting and/or burning in tropical forests, but mainly concerning nutrients losses (Jordan 1987). Some results have been published on the effects on pedofaunal communities during the first stages in a vegetation succession (e.g. diversity index: Takeda 1981, Betsch & Cancela da Fonseca 1984, Betsch et al. 1990) or by analysis of regrowths at three or four different stages (Silva del Pozo & Blandin 1991). Our purpose was to study in detail the evolution of the major components of the soil mesofauna in relation to some important ecological factors after a strong disturbance.

2. Experimental plots

An experimental parcel (ARBOCEL) in a subequatorial rainforest in French Guyana (5°30′N, 53°W, altitude about 50 m, mean temperature 28°C, rainfall 3500 mm/year, litter fall 8 t d.m. /year) was clear-cut and partly burnt in the dry season of 1976. The study includes a control plot (50 m inside the evergreen forest) and 5 plots of natural regeneration (50 m inside the parcel) along a transect. The soil was ferralitic (pH about 4.5) with a thin layer of humus and a superficial natural drainage (Humbel 1978). The plots studied were an unburnt plot (NB) which soon became similar to the control forest (CT), and 4 plots (B1 to B4) along a very short transect (5 m) through a strongly burnt place. After burning, the soil contained the mineral layer only; the 4 plots received their first litter from the peripheric NB regrowth during dry season 1979 (B1, B4), 1980 (B3) and 1987–88 (B2). In 1992, the burnt plots were effectively restored (Table 1). All burnt soils showed an inverse hydric profile during the first 2–3 years (surface layer dryer than deeper ones). Progressively they reattained the moisture profile typical to control forest (Fig. 1).

Table 1. Litter (Collembola) and vegetation characteristics in the rainy season of 1992 in unburnt (NB) and strongly burnt (B1 to B4) sites (n.d. = not determined). *H′* = diversity index.

	B1	B2	B3	B4	NB
H′ Collembola	2.11	1.90	2.12	2.05	2.14
Litter (g/800 cm^2)	113	129	197	153	244
Vegetation height (cm)					
mean	75	25	35	65	n.d.
max	100	45	50	150	1500

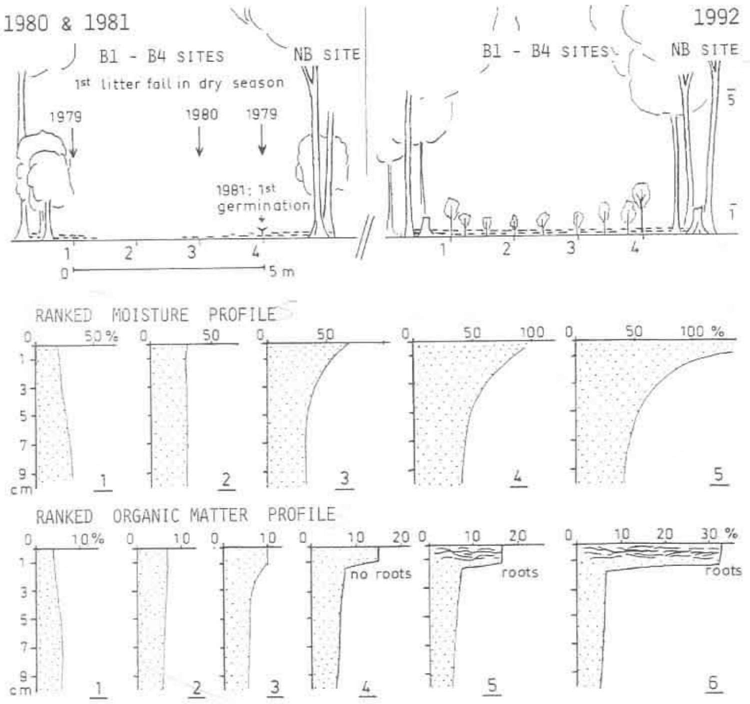

Fig. 1. Schematic presentation of moisture and organic matter profiles ranked from inverse, undeveloped (1; recently burnt plots without litter layer) to fully developed (5/6) in unburnt (NB) and strongly burnt (B1 to B4) sites (ARBOCEL parcel). These ranks are used in the correlation analyses.

3. Methods

Sampling was carried out in the rainy seasons of 1977 (1 year after clear-cutting), 1978 (2 years), 1980 (4 years), 1981 (5 years) and 1992 (16 years). 3 litter samples with a surface area of 800 cm², and 3 soil cores with a surface of 60 cm², subdivided into 4 layers (H1 0–1, H2 1–3.5, H3 3.5–6, H4 6–8.5 cm) were taken once per year. Microarthropods were extracted using the Tullgren (dry funnel) method. The analyses were made at two hierarchical taxonomic levels:

1) Collembola divided in 5 groups: Neelidae (NEE), Symphypleona s.str. (SY1), Poduromorpha (POD), Entomobryidae (ENT) and Isotomidae (ISO); and
2) Microarthropods divided in two groups of Collembola, Symphypleona s.l. (SY2) and Arthropleona (ART), and two groups of mites, Oribatida (ORI) and other Acarida (AC1).

Spearman rank correlation analyses were made between faunal groups and ranked organic matter profile, and between faunal groups and moisture (mean value in 0 to 8.5 cm, ratio H1/H4, and ranked profile). The faunal groups in litter were correlated with the soil factors because of the interdependance of litter and soil. In 1980 and 1981 the fauna of the unburnt and burnt sites were compared using the Mann-Whitney *U*-test. To characterize each site by all faunal groups, correspondence analysis was used. The contribution of each group in explaining each factor was calculated to indicate the relative importance of the groups.

4. Results

In the first stages of soil recovery (Table 2), the unburnt control site NB (litter fall before 1979) differed from the adjacent burnt site B4 (first litter 1979) only in the composition of the Collembola community in 1981. Moreover, a burnt plot covered by litter (B1) differed from a burnt plot without litter (B3) in 1980 in the composition of both microarthropods and Collembola communities. But, when a burnt plot (B1, B3, B4) is covered by litter, even at different times, these community compositions did not differ from each others.

In the litter the majority of the groups showed negative correlations with moisture and organic matter of the soil during the first stages of soil recovery. In Collembola most of the correlations changed to positive after full soil recovery, while in mites the negative correlations gener-

Table 2. Mann-Whitney *U*-test between the litter faunas of Collembola (5 groups) and microarthropods (4 groups) of unburnt (NB) and strongly burnt (B1 to B4) sites (* and ** = significant at $P < 0.05$ and $P < 0.01$).

	Collembola	Microarthr.
B1 vs B3 / 1980	0 **	0 *
B1 vs B3 / 1981	6 ns	5 ns
B4 vs NB / 1980	9.5 ns	5 ns
B4 vs NB / 1981	4 *	5 ns

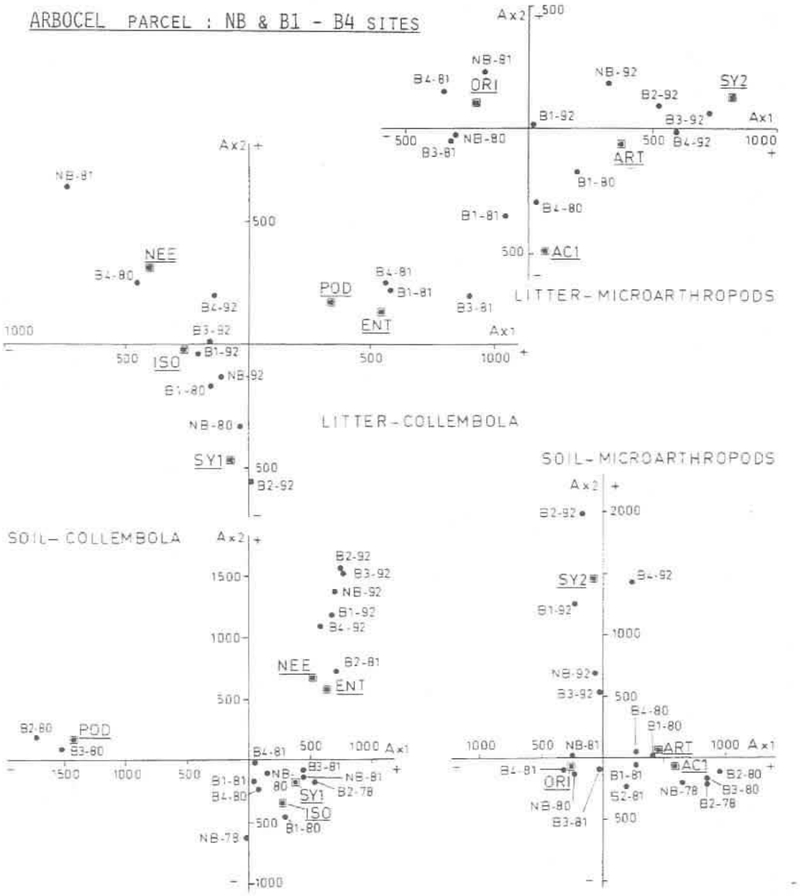

Fig. 2. Correspondence analysis applied to faunal groups (Collembola: NEE = Neelidae, SY1 = Symphypleona s. str., POD = Poduromorpha, ENT = Entomobryidae, ISO = Isotomidae; microarthropods: SY2 = Symphypleona s. l., ART = Arthropleona, ORI = Oribatida, AC1 = other Acarida) per site and per year in litter (1980–1992) and soil (1978–1992). (NB = unburnt, B1–B4 = burnt sites).

ally increased. In the soil, the general tendency was loss of positive correlations with edaphic factors, except in Neelidae which maintained positive correlation during the whole period (Table 3).

The water content (Fig. 1) at the beginning of the study period was medium in the unburnt plot (profile 3) but low and inversed in the others (profile 1). The stable profile of NB (1977–1981) was the main characteristic

Table 3. Sign of Spearman rank correlation applied to Collembola and microarthropod communities in litter (L) and soil (S) versus edaphic factors in the unburnt (NB) and strongly burnt (B1 to B4) sites. * and ** = significant at $P < 0.05$ and $P < 0.01$.

	1980–1981								1978–1992							
	Water content				Moisture profile		Organic matter		Water content				Moisture profile		Organic matter	
	mean		H1/H4						mean		H1/H4					
	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S
Collembola																
Neelidae	–	$+^{**}$	–	+	–	+	–	$+^{**}$	$+^{*}$	$+^{**}$	$+^{*}$	$+^{*}$	$+^{*}$	+	$+^{*}$	$+^{**}$
Symphypleona s. str.	$-^{*}$	+	–	–	–	–	–	+	$+^{*}$	+	$+^{*}$	–	$+^{*}$	–	+	+
Poduromorpha	+	+	–	–	+	–	–	+	–	–	–	$-^{**}$	–	$-^{*}$	–	–
Entomobryidae	–	+	+	$+^{**}$	+	$+^{**}$	–	+	+	+	$+^{*}$	+	$+^{*}$	+	+	+
Isotomidae	+	$+^{*}$	–	+	–	+	+	$+^{*}$	+	–	–	–	–	–	+	–
Microarthropods																
Symphypleona s. l.	–	$+^{**}$	–	+	–	+	–	$+^{**}$	$+^{*}$	$+^{**}$	$+^{*}$	+	$+^{*}$	+	$+^{*}$	$+^{*}$
Arthropleona	+	+	+	+	+	+	+	+	+	–	$+^{*}$	–	$+^{*}$	$-^{*}$	+	–
Oribatida	+	$+^{**}$	+	+	$+^{*}$	$+^{*}$	+	$+^{**}$	$-^{*}$	–	+	–	–	–	–	–
Acarida (others)	–	$+^{*}$	–	–	–	+	–	+	$-^{**}$	–	$-^{*}$	$-^{*}$	$-^{*}$	$-^{*}$	$-^{**}$	–

Table 4. Evolution of the ranked moisture and organic matter profiles in the soil (0–8.5 cm), in the control forest (CT), unburnt (NB) and strongly burnt (B1 to B4) sites (see also Fig. 1).

	1977	1978	1980	1981	1992
Moisture					
CT	5	5	5	5	5
NB	3	3	3	3	5
B1	1	1	2	2/3	4
B2	1	1	1/2	2/3	5
B3	1	1	1	3	5
B4	1	1	1	4	5
Organic matter					
CT	6	6	6	6	6
NB	5	5	5	5/6	6
B1	1	2	2	2/3	6
B2	1	2	2	1	5/6
B3	1	2	2	4	6
B4	1	2	3	5/6	6

which differentiated this site from the others. The moisture increased slowly in B1 and B2 from 1980 onwards, and more quickly in B3 and B4 starting from 1981. The burnt plots except B1 attained a fully developed profile (5) in 1992 (Table 4). The organic matter profiles (Fig. 1) were inversed in 1977 in all the burnt plots. In 1992, a fully developed profile (6) was attained in all sites except B2, which still showed an inverse profile in 1981, 4 years after burning (Table 4).

In the litter the most characteristic groups among Collembola were Entomobryidae in sites B3, B4 and B1 in 1981, Neelidae in NB in 1981 and Symphypleona s.str. in B2 in 1992. The duration of the soil recovery was the factor controlling the Collembola community during the pioneer stage (1981), but only the second one in the young secondary forest (1992). Each one of the major groups of microarthropods was the most important but at different times for each plot. The different ecological reactions of springtails and mites against moisture and organic matter (Table 3) were more important factors (Ax1) than the duration of the soil recovery (Ax2) (Fig. 2). In the soil the most representative Collembola groups were Poduridae in B2 and B3 and Isotomidae in B1 in 1980, and Neelidae and Entomobryidae in B4, NB and B1 in 1992. As in the litter, the importance of each microarthropod group differed in time and space. The most important factors were the coverage of soil by litter (Ax1) and the duration of the soil recovery (Ax2) (Fig. 2).

5. Conclusion

The process of soil recovery after burning includes changes in several correlations between soil moisture, organic matter and the different microarthropod groups. These faunal groups, though being present at the same time in the different sites, are not necessarily characteristic of them at the same period. After a recovery period of 16 years, the different faunal groups were more or less equally represented in the litter of the different sites, while in the soil this was not the case (perhaps due to a delay, in 1992, of the beginning of the rainy season).

References

Betsch, J. M. & Cancela da Fonseca, J. P. 1984: Species diversity in soil insects, micro-arthropods and macro-fauna. — In: Maury-Lechon, G., Hadley, M. & Younes, T. (eds.), The significance of species diversity in tropical forest ecosystems, IUBS sp. issue 6:30–44.

Betsch, J. M., Kilbertus, G., Coûteaux, M. M. & Vannier, G. 1990: Microflore et faune du sol: indicateurs biologiques de la transformation de la forêt tropicale humide en agrosystèmes. — In: Sarrailh, J. M. (ed.), Mise en valeur de l'écosystème forestier guyanais (Opération ECEREX): 209–270. INRA-CTFT eds., Paris.

Humbel, F. X. 1978: Caractérisation, par des mesures physiques, hydriques et d'enracinement, des sols de Guyane française à dynamique de l'eau superficielle. — Sci. Sol 2: 83–93.

Jordan, C. F. 1987: Amazonian rain forest. Ecosystem disturbance and recovery. — Ecol. Studies 60. Springer Verlag. 133 pp.

Silva Del Pozo, X. & Blandin, P. 1991: Les peuplements de Macroarthropodes édaphiques à différentes étapes de la reconstitution de la forêt mésothermique en Equateur occidental. — Rev. Ecol. Biol. Sol 28:435–442.

Takeda, H., 1981: Effects of shifting cultivation on the soil meso-fauna with special reference to Collembolan populations in North-East Thailand. — Mem. Coll. Agric. Kyoto Univ. 118: 45–60.